and precipitous gorges that contribute so much to the charms and scenic effects of a region.[1]

T. A. BENDRAT, M.S.

CONSTABLEVILLE, N. Y.

THE AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE HANOVER MEETING, SECTION E, JULY 1-3, 1908

AT the Hanover meeting of the American Association for the Advancement of Science, Section E, Geography and Geology, held two sessions for the reading of papers and participated in the excursions to Mt. Ascutney and Corbin Park. Prior to the gathering at Hanover, a party of geologists, which varied in number from eight to ten, enjoyed a trip from Bellows Falls, Vt., to Rutland under the guidance of Professor J. E. Wolff, to the marble quarries at West Rutland with Mr. G. H. Perkins, state geologist, and from Rutland to Woodstock in company with Professor Wolff and Professor C. H. Hitchcock.

The scientific sessions began Tuesday, June 30, at ten o'clock and, with an intermission for dinner, continued till 4:30 P.M. Mr. Bailey Willis, vice-president, called the meeting to order. In the absence of the sectional secretary, Dr. F. P. Gulliver, who was unfortunately too ill to attend, Professor J. E. Wolff consented to serve as secretary. After the opening of the afternoon session, Professor C. H. Hitchcock took the chair at the request of Mr. Willis and presided to the close of the session. The following papers were presented and discussed:

Local Geology of Hanover, N. H.: C. H. HITCHCOCK.

Professor Hitchcock after referring to his early work as state geologist and its continuation during forty years, described a large relief map of New Hampshire which he had prepared and from time to time brought up to date as geological investigations progressed. It is now colored to represent the state of knowledge in 1908. The accumulated collections and their arrangement in the Butterfield Museum of Dartmouth College were described, and attention was called to the device of connecting each specimen by an identical number with its locality shown in one of the eighteen sections, which had been prepared on a large scale to illustrate the relations of the rocks. Professor Hitchcock then stated in some detail the known and probable relations of the various igneous and metamorphic rocks of the Hanover quadrangle and showed a preliminary draft of a geologic map of that area. The strata being, so far as known, unfossiliferous, their age is inferred from comparison with related fossiliferous sections, which indicate that Cambrian, Ordovician and Silurian rocks may be present in the geosyncline that lies east of the Pre-Cambrian axis of the Green Mountains and extends into the western half of the Hanover quadrangle. The eastern half is a complex of intrusive and metamorphic rocks, on the western margin of a large area related to the zone of intrusions which traverses the middle of New Hampshire and culminates in the White Mountains. Passing on to the subject of glacial geology, the speaker described two sets of striæ, the one ranging south 10° west down the Connecticut Valley, the other southeast. Evidence that local glaciers occupied the valleys tributary to the Connecticut after the disappearance of the general ice sheet was briefly presented, and incidentally a map of Connecticut on a scale of 400 feet to the inch, prepared by the students of Dartmouth, was exhibited.

In discussion Mr. Willis stated that wide areas of schists and gneiss of New England, which were formerly considered to be Archean, are now generally classed as Paleozoic sediments and intrusives. These do not include the axis of the Green Mountains, which Professors Hitchcock and Wolff had described as Archean, but they cover all the province east of that range in Vermont, New Hampshire and Maine.

Recent Explorations in Mammoth Cave, with a Revised Map of the Cave: HORACE C. HOVEY.

Mr. Hovey stated that, of late, explorations in the unfrequented parts of Mammoth Cave have been pushed by several visitors, especially Messrs. Parrish and Einbigler, aided by the local guides. The results were laid before the author of this paper, who verified them by a personal visit in 1907; finding the newly discovered domes more grand than any previously known. These additions, and a number of minor corrections, had led him to prepare a new guide map, with an index and table of approximate distances, which he had now published and exhibited in connection with this paper. Dr. Hovey courteously presented copies of the new map of Mammoth Cave to those present at the meeting of the section.

The Warm Stratum existing at a Great Height in the Atmosphere: A. LAWRENCE ROTCH.

In 1901 it was discovered in Europe, by the use

[1] This article is a chapter of a report to be published on the geology of Lewis County, based on three seasons of field work.

of "ballons-sondes," that there was a warm, or isothermal, stratum in the atmosphere at a height of about 10 kilometers. In 1904 the author made the first use of "ballons-sondes" in the United States and in this and the following years sent up 77 balloons from St. Louis. Nearly all of the 71 recovered which rose higher than 12 kilometers entered the warm stratum. The largest inversion of temperature found was during the first ascension on September 15, 1904, when the minimum temperature of —52° C. occurred at a height of 14,600 meters, the temperature rising to —36° C. at 17,000 meters, the maximum height attained. Again, on October 8, 1907, the temperature fell to —67° C. at 14,500 meters and rose to —58° C. at 16,500 meters, the stratum of inversion descending 2,500 meters within the next two days. In summer its level is somewhat lower than at other seasons. It seems probable that this warm stratum extends completely around the globe. It lies lower in northern Europe, but it was not discovered at the equator by the balloons that rose 15 kilometers from a yacht sent to the South Atlantic in 1906 by M. T. de Bort and the author.

Discussed by Professor T. C. Chamberlin.

High-level Terraces of New England: J. W. SPENCER.

The author presented and described longitudinal sections of the river valleys radiating from the White Mountains. They show a succession of terrace steps descending the valleys, the surfaces of which slope very gently down the valleys, each one passing by abrupt transition to the next below. Each begins in a river flat, becoming a terrace further down the stream, where remains of several terraces, one above the other, may be seen. In one case, as in the Lemaile Valley, the slope was found to be forty-five feet in fifteen miles. These phenomena are found from the high mountain passes, such as Profile and Crawford notches, to within a few hundred feet above sea level. They suggest that in them be found data bearing on the Post-glacial elevation of the mountain masses.

Discussed by Professor J. W. Goldthwaite.

Note upon the Structure of the Pre-Cambrian Gneiss of the Santa Catalina Mountains, Arizona: WM. P. BLAKE.

The Pre-Cambrian gneiss of the Santa Catalina Mountains is remarkable for its tabular stratification at a low angle of dip; its permeation by pegmatite with the formation of feldspar nodules, and its extreme foliation in some parts, passing from coarse-grained gneiss to schists in various forms, micaceous and hornblendic.

But the chief characteristic to be here noted is its evident elongation under great pressure.

Studies of the Tracks of Climatichnites: C. H. HITCHCOCK and W. PATTEN.

A large slab of sandstone crossed by several trails was exhibited where installed on the walls of Butterfield Museum. Professor Patten described the movements of a modern *Limulus* in advancing up a sandy beach with the tide and the action of the abdominal gill plates making rhythmic ridges in the sand. He compared these with the tracks of Climatichnites, which he ascribed to forms related to the Eurypterids rather than the trilobites. The tracks showed a beginning in a hollow in the sand and where continued on the specimen to the further end there became fainter, as if the animal rose from the bottom. This would correspond with the habit of the *Limulus,* which remains buried on recession of the tide and upon its return first crawls and then swims away. Beside one track were seen two symmetrically placed impressions attributed to the longer arms of a Eurypteroid form.

The Attitude of the Algonquin Beach; and its Significance: J. W. GOLDTHWAITE. (Illustrated by lantern slides.)

Precise measurements of altitude of the Algonquin beach and other "raised beaches" bordering Lake Michigan indicate that in that basin the Algonquin beach slants southward at a repeatedly diminishing rate, becoming horizontal near Manistee, Mich., and Kewaunee, Wis. South of a line through these localities the Algonquin beach is invariably 593–598 feet A. T. This horizontality over the southern half of the Lake Michigan basin appears to mean that the beach there is now at the altitude at which it stood when first formed, and that it has been undisturbed by those differential uplifts which have warped the more northerly parts of the Great Lake district. In other words, Lake Algonquin appears to have stood approximately 600 feet A. T. when the "Algonquin Beach" was built.

Mr. F. B. Taylor found what is probably the same beach at an altitude of 1,220 feet A. T. near South River, 30 miles south of the pass between Lake Nipissing and the Mattawa River. It is quite possible that the plane of this Algonquin beach, extended over the Nipissing Pass, would be at least 1,300 feet A. T. there. If so, that dis-

trict has risen approximately 700 feet since the beach was formed.

If we restore the district near the Nipissing pass to the position which it had at the Algonquin stage, by lowering it 700 feet below its present position, we put the floor of the Nipissing pass (which is now less than 700 feet A. T.) a little below sea level. This suggests the possibility that the sea may have entered the basins of the Great Lakes from this direction.

The conjectured altitude of Lake Algonquin, 600 feet A. T., is attributed to an ice barrier over the Nipissing pass. It is very probable that this barrier persisted until the floor of the pass had been raised well above sea level, by the differential uplifts which produced the diverging series of beaches below the Algonquin. If the sea did come in through the Nipissing Pass, however, a record of it might be expected in raised beaches north of the pass.

Professor Goldthwaite was followed by Dr. J. W. Spencer, who presented the two following papers, both of which were illustrated by lantern slides.

Changes in the Recession of the Falls of Niagara.

The following is a mere summary of some of many chapters required in describing phenomena which bring to light the changing features of Niagara Falls.

From my own measurements of the recession of Niagara Falls, compared with those of Hall in 1842, I find that the average rate is 4.2 feet a year for the width of the canyon (1,200 feet) made by the cataract; and from the discovery of its position in 1678, approximately the same rate formerly prevailed.

From a point 1,100 feet below the apex of the falls, to the Whirlpool, I find by my new soundings, that the depth of the gorge reaches to the same plane of 86 to 92 feet below the level of Lake Ontario, when allowance is made for the descent of the river surface at the Whirlpool Rapids, where borings show that the canyon was trenched to the same depth as above and below them by the falls. But soundings, which I succeeded in making immediately below the falls themselves, prove that the cataract can excavate to a depth of not over 100 feet below the river surface, consequently the present deep channel of 186 to 192 feet could have been made only when the falls were higher—that was before the gorge at the Whirlpool Rapids had become partly refilled by the recent falling of the adjacent wall-rocks. At this section, for a short time, the volume of the river was diminished by the temporary partial diversion of the Upper Lake drainage, by way of Chicago. Until the falls had crossed the Lyell ridge, about a mile and a half below their present site, they were somewhat higher than now. By the trenching of this ridge the surface of the river was lowered by about sixty feet, on account of the removal of the drift from the pre-glacial valley, which they took possession of, whereupon the Upper Rapids came into existence. The site of the Whirlpool was the head of a pre-glacial canyon, above which was a small tributary heading in the Lyell ridge, two miles away, since deepened by the falls. Below the whirlpool to the head of Foster's Flats (about two thirds of a mile), the gorge is similar to that above, and here there was a slight change in the height of the falls, as explained. Throughout these four miles the greater height of the falls increased the rate of recession. By differentiating the work of the falls at each point, the time required for the formation of this longitudinal stretch of the gorge is now computed to have been 3,500 years only.

The history of the lower three miles is entirely different. At their birth, the falls were only 35 feet high—shown by a terrace at the mouth of the gorge. From time to time the falls increased in height as the Ontario waters retreated to lower levels, even to 180 feet below the level of the present day—shown by the deep inner channel revealed by my recent soundings. The falls then reached over 500 feet in height, but consisted of three separate cataracts, the lowest of which was over 300 feet high; however, its work as rapids was exhausted in excavating a new channel for over eleven miles beyond the end of the gorge, while the upper cataracts were already far advanced within the canyon. Shortly after the third cataract, now a fall, had receded half a mile within the gorge, its height was reduced by nearly 180 feet, owing to the rising of the Ontario waters, due to the warping of the earth's crust at the outlet of the lake.

The second cataract gained upon the upper one, until the two united at a well-marked point at Foster's Flats, less than three miles from the mouth of the gorge. At this time they had each reached about 120 feet in height. A few hundred feet beyond this point, at the head of the flats, occurred the most remarkable change in the history of the river. Until this time the volume of the river was only that of the Erie drainage, the three upper lakes emptying to the northeast, as

I discovered in 1888. The volume of the Erie drainage is now found to have been only 15 per cent. of the present discharge of Niagara River. The change mentioned consisted of a new force breaking through the hard sandstone floor of the river to a great depth, as found by the new soundings, and making a much greater channel than the united falls had been able to produce. This increased force arose from the addition of the full discharge of all the upper lakes, which is now thus established to have taken place, when the falls were at this point.

Throughout this lower section of about three miles, the work performed by the upper cataract has been determined. Therefore, by applying the laws of erosion, it became possible to calculate the approximate age of this section of the gorge. Had it been necessary to depend upon the work of the second and third cataracts, it is hardly likely that any reliable determination could have been made. The results show that a period of 35,500 years was required for the recession of the falls in this lower section or 39,000 years in the whole length of the canyon.

The turning of the Huron drainage into Lake Erie occurred 3,500 years ago, and it is 3,000 years since the falls reached the whirlpool. They were passing the site of the Whirlpool Rapids from 2,500 to 2,000 years ago, while the rapids themselves were completed less than 300 years since.

Pre-glacial Erie Outlet.

The Erie Basin formed a depression in the Devonian shales, bounded on the north by a narrow ridge, capped by Corniferous limestone. This was faced on its northern side by a low escarpment, descending to the basin in the soft rocks of the Salina formation, which was bounded on its northern side by durable Niagara limestone. The escarpment and basin mentioned are now leveled over by drift formations. Beyond the Niagara limestone there was again a parallel trough of the Ontario basin, excavated out of soft Medina shales. Such was the pre-glacial character of the Niagara peninsula between Lake Erie and Lake Ontario.

Many years ago I found that the ridge of Niagara limestone, at the head of Lake Ontario, was trenched sufficiently deep to at least draw water from the Erie basin. Another trench to a depth of 28 feet below the surface of that lake occurs along the Welland Canal.

Upon investigating the character of the rock-bound basin at Niagara Falls, I found that it did not lead to the north, as was supposed, but rapidly widened and deepened to the southwestward, even to one hundred feet below the surface of Lake Erie. Determined to find whither this pre-glacial valley led, I collected the records of borings, and made other borings, with the result that a deep pre-glacial valley was discovered cutting the Corniferous limestone for a breadth of less than two miles, immediately east of Lowbank Post Office, and crossing the Salina basin, and again trenching the ridge of Niagara limestone (here forming a canyon) filled with drift, but partly reopened by the modern streams, just west of De Cou Falls, the inner canyon being somewhat more than a mile, and the outer more than two miles in width. With allowance for the measured post-glacial uplift, this buried valley, revealed by borings at almost every mile, was sufficiently deep to drain the pre-glacial Erie valley, receiving, as it did, the ancient Ohio and Alleghany rivers as tributaries. These gorges through the hard ridges between the buried valleys resemble the courses of streams crossing the Appalachian ridges. The discovery of this ancient water course is one of the most completely demonstrated of all those bringing to light the great changes of drainage since pre-glacial days, and is a lesson for further research.

This closed the sectional meeting.

The excursion to Mount Ascutney, Wednesday, July 1, was shared by twenty-two members. A number accompanied Dr. Daly in a drive about the base of the mountain and to Little Ascutney to examine the igneous rocks and contact phenomena. The others ascended the principal height. In the view from the summit the oldest recognizable peneplain of the region was studied and certain differences of opinion as to its character were developed. To some of those present, the reduction of the surface toward a general peneplain appeared less complete than had been expected, and the appearance of the topography suggested that of certain mid-Tertiary slopes and heights.

From the excursion to Mount Ascutney members of Section E returned to Hanover to take part in the general exercises, including the trip to the Corbin Game Park on Thursday, July 2.

On Friday and Saturday a number proceeded from Hanover to Littleton, N. H., under the guidance of Professor Hitchcock, and examined the stratigraphy of the Silurian rocks, from which trilobites and brachiopods were collected.

Bailey Willis